21st Century Real-World Robotics

SUMMARY

Building robots with viable programming and color sense capacities becomes a reality in this project-based, interdisciplinary learning unit for middle-level students in Brooklyn. This school employs both team teaching and collaborative learning in its dynamic approach to teaching science and technology.

Throughout his extensive research into the 21st century instruction possibilities of robotics, Mark Gura, Touro professor, author of several books on Lego robotics and founder of the Classroom Robotics blog, notes that Robotics challenges are a perfect vehicle to promote communications, collaboration and other skills essential to 21st century learning. Roboticist practitioners, Gura notes, need to communicate as they work together to journal their efforts and solutions (2007). Working from manuals, instructions, and programming the robots authentically involves 21st century real-world principles and functions of academic and special domain knowledge.

Robotics problem challenges are readily applicable to today's world. For example, robots are being used to search for missing planes and to destroy hidden mines. Students experience real-world seamless science, engineering, and cross-discipline problem-solving as they program the robots. Teachers collaborating from more than one content area to seamlessly model that in their instruction validate the cross discipline 21st century learning opportunities for robotics, which Gura stressed should be part of regular school day interdisciplinary learning (2012).

At Ditmas Intermediate School 62 in Brooklyn, technology teacher Angelo Carideo and David Liotta, a social studies and media studio teacher, set sixth graders off on a mission to build

Rose Reissman is a literacy support specialist and director of the Writing Institute at Ditmas Intermediate School 62 in Brooklyn.

Angelo Carideo is a technology and law teacher at Ditmas IS 62.

David Liotta is a media and social studies teacher at Ditmas IS 62.

Amanda Xavier is an ELA teacher at Ditmas IS 62.

Sofia Rashid teaches ESL at Ditmas IS 62.

Irene Huerta is a special needs paraprofessional at Ditmas IS 62.

Rose Reissman, United Federation of Teachers
Angelo Carideo, United Federation of Teachers
David Liotta, United Federation of Teachers
Amanda Xavier, United Federation of Teachers
Sofia Rashid, United Federation of Teachers
Irene Huerta, United Federation of Teachers

team robots with viable programming and color sensor capacities. Their collaborative teaming makes this Science, Technology, Engineering and Mathematics-infused robotics project thrive. Students work, communicate, and collaborate in teams to accountably produce a functioning robot. They later showcase their robots and present their work at a multi-project Writing Institute Expo run by Rose Reissman with the support of fellow Ditmas educators Liotta, Carideo, Amanda Xavier and Sofia Rashid.

The Ditmas robotics project is grounded in the research of Khanlari (2013) and Demetriou (2011), who note that the "use of robotics . . . can improve students' personal skills . . . problem-solving, communication, creativity, decision making, and teamwork" — all 21st century learning skills and outcomes. Furthermore, by interviewing seven teachers who taught robotics, Khanlari, in his study of the "Effects of Robotics on 21st Century Skills" suggested "that robotics can be used as an effective tool to improve 21st century skills, including students' creativity, collaboration and team working, self direction, communication skills, and … social responsibilities."

The Ditmas student robot project is done during the school day and involves the ELA educator, the literacy specialist and the ESL teacher. The teachers team to plan and to infuse — as the project progresses — specific literacy and second acquisition skills plus differentiated learner options so the project is "part" of an interdisciplinary end product-centered initiative which mirrors requirements of a 21st century workplace skills set.

Students experience real-world seamless science, engineering, and cross-discipline problem-solving as they program the robots.

Faculty Team Collaboration

Ditmas is a school whose culture is built upon collaboration. Principal Barry Kevorkian, who has spent more than three decades at Ditmas as a team teacher, assistant principal, coach, dean, and group leader, explains this culture: "Teachers can share thoughts and ideas and help one another to become more effective. The teachers'

continued on following page

Team teaching: A model in collaboration

The success of the Ditmas robotics project is due in no small part to the cross-curricular, team-teaching approach employed by the authors. The educators met throughout the project to brainstorm how the project could meet the needs of all students involved.

When one educator suggested the robotics theme could be introduced to special needs students by having them focus on science fiction literature about robots, other educators on the team readily piped in with their ideas:

- Reissman, the literacy specialist, suggested Isaac Asimov's first story, "Robbie," written in the 1950s.
- The technology teacher, Carideo, noted students could update the story to the 21st century and script their own versions for a podcast.
- Huerta, a paraprofessional who extensively supports ELA development in spoken and written language, saw this as an opportunity to develop a product that would captivate her students and enhance their collaboration, communication, problem-solving, and critical thinking skills by using an approachable text.
- ELA teacher Xavier noted that even though the robotics project had only been funded for one group, having her inclusion classroom work with a commercially purchased robotics kit would also enhance and support Common Core learning.

In their planning meetings before and during the project, the educators themselves were active participants in the same behaviors they were teaching the students. This modeling of adult teacher discussion of the project challenges and opportunities for multi-content integration inspired the educators to help the students realize important life skills of taking initiative and being self-directed as they took on the robotics challenge.

actual collaboration models and supports their students to in turn grow academically, emotionally, and socially. These 21st century learning communication styles make students who 'team' better prepared for college and careers. To be successful on an economic, community or personal level, students need to experience collaboration themselves and are doubly enhanced by working with a team of joyously collaborating educators. As a principal and a former teacher ... I facilitate their collaboration and coordination of efforts on behalf of the school. To me the essence of leadership is collaboration of all team members and our staff model this real-world essential style for students."

As a result of their mutual ongoing creative and academic success with schoolwide programs, Carideo and Liotta were invited to work together on the robotics building project. They also worked with other educators to discuss how ELA, special needs, and ESL talents could be highlighted and engaged by the project.

The collaborative teaching team of Carideo, Liotta, Reissman, Xavier, and Rashid, represents teaching across the content areas (ESL, ELA, and CIT). In regularly scheduled team-teaching meetings, the educators discuss how Common Core ELA standards such as reflective journal writing and speaking and listening skills can be used to help students realize their 21st century learning goals. The team planned an introductory discussion for the robotics group of sixth graders, which includes some students who display Asperger behaviors, some ESL students, and a broad range of students with differentiated learning styles. The

team teachers use small groups and conferencing as part of their teaching so they can support the individual student groups by walking around and facilitating (Danielson framework, Domain 3). Groups are also constructed to support student strengths. In one student group, for example, a student who displays Asperger behaviors is identified as the videographer so he has to socialize with others; another student will "report" for the school television program as she is a visual learner and a natural on-camera performer.

A robotics project lends itself to myriad technical terms — *actuator, rotary, application, input, sensors, interface, linear, android* — and can help to develop academic and social language as students work together in small groups. Even where the words are somewhat familiar from science fiction or other technology kits or games, this project — with its attention to the manual-specific directions and need to get the special domain meaning of the specified robot function exact — forces students to learn the special domain-targeted robotics vocabulary, much as they will need to master job or workplace vocabularies as adults. This develops vocabulary as a necessary condition of robot-building success.

Reflection journals — student portfolios and artifacts — were especially beneficial to ESL students as they learned to express themselves in English using academic language. CIT (Collaborative Integrated Teaching) classes could work on argumentative pieces to defend their robot as the best challenge solution. The more verbally outspoken students could lead the way, while those with an Individualized Education Program used sentence frames to contribute their argument details.

The Robot Challenge Begins

With the teacher team having developed a framework, the students actually began their 21st century collaboration, critical thinking, and creativity. The robotics class was told from the start that they would be working in small groups to achieve the end product of constructing a functioning robot.

continued on following page

First, there is a discussion on 21st century learning and innovation skills: creativity, innovation, critical thinking, problem-solving, communication, and collaboration. They are also taught about 21st century life and career skills such as flexibility, adaptability, initiative, self-direction, social and cross cultural skills, productivity, accountability, leadership, and responsibility.

The students get the kit and a deadline for building the robot to function and be presented for rubric-aligned assessment. They have to decide how to tackle the challenge. They self-direct and generally appoint a group leader to supervise and divide tasks of building, recording, group meetings, and addressing frustrations as the project evolves. The teachers may suggest students look at specific parts of the manual or work as a team to brainstorm solutions for problems that come up, but do not actually intervene or help them.

In their teams, students had to be flexible as they worked with others to follow the instructions in the manual. They had to adapt to one another's learning style and style of work. They had to be self-directed if members of the team did not work together. Some had to assume leadership and take responsibility for getting the robot ready to perform and function by the deadline date.

Each team member had to collaborate, communicate and often create solutions when what they did at first did not "work." Much of their effort involved "fixing" a part or aspect of the robot and dealing with the frustration that required another potential intervention strategy.

In their small groups, the students focused on how to interpret these special 21st century words into ongoing writing assignments and discussions. Before breaking up into small groups, a large group team meeting focused on the project objectives.

Throughout the process, students take notes for their journal entries and, with personal comments, can reflect on the team's progress as a whole. Some students enjoy recording, while others "voice" the material. Some illustrate or draw cartoons.

Excerpts from students' written work and discussions (voiced in formative and summative assessment journal responses) demonstrate powerful learning outcomes.

21st Century Flexibility

Just as with complex jigsaw puzzles and in real life when you plan an event, teach a class, or run a company, issues come up which were not and cannot be anticipated. Unlike some simpler erection or science kits students may have played with, the robotics kit is not assembled easily or immediately. Some students felt they had "lost" pieces, or they were "following instructions precisely," yet the parts did not fit. In addition, just as in any adult life enterprise or social effort, some students assigned specific roles do not come through and others have to pick up the slack. Many discussed how hard it was to execute the step-by-step programming detailed. They talked about team members who took over — or deserted. They journal anger at members who dominate, not collaborate. Khaliphkai noted that many within her group were focused on the building, but not the programming of the robot, an issue of accountability. Lizbeth revealed that the concept of teamwork in building the robot did not excite her since she wanted to work alone.

For some, this exercise highlighted the efficacy of being flexible. Others saw how they might need to develop that quality or suffer the consequences when things did not work out as they wanted.

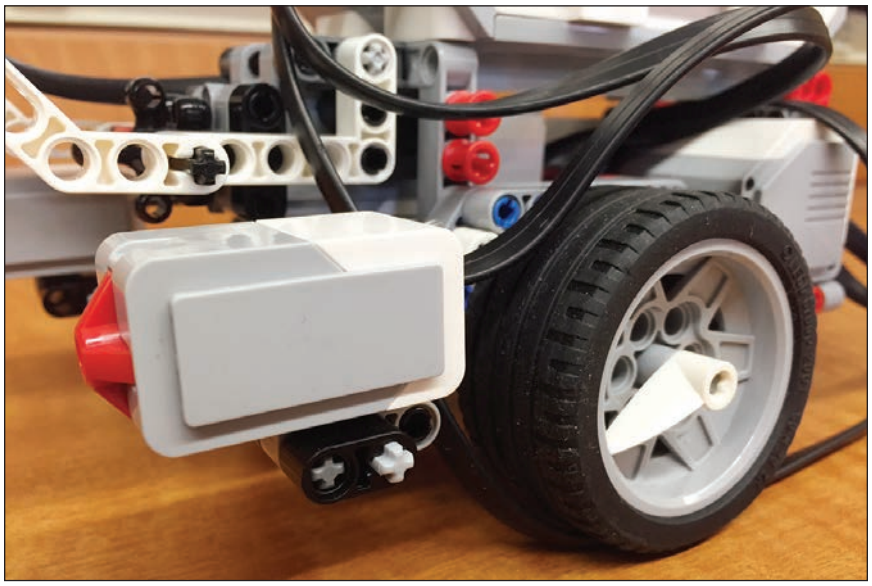
Missing Pieces

The project has an explicit emphasis on problem-solving, critical thinking, flexibility, self-direction, accountability, responsibility and leadership skills. The following passage describes a snapshot of students working with their robots in the classroom:

> *Janiah actually got to the point of thinking about "breaking the robot" because it "would never work."*
>
> *Yarellis noted that parts in the box refused to go in properly, although obviously they were manufactured for the robot.*
>
> *Theresia put it literally, not realizing she had come up with an apt metaphor for the process and its frustration: "One ... problem we had is the missing pieces. One day we had all the pieces; the next day, we don't."*
>
> *One team found they had installed the parts incorrectly and needed to change the wires.*
>
> *Other groups were upset after having done so much work to discover that there was still more work.*
>
> *Khaim's group found it exceedingly frustrating to get the robot codes to actually result in the robot making a full turn.*

continued on following page

Robotics are a perfect vehicle to promote communications, collaboration and other skills essential to 21st century learning.



Just underscoring 21st century skills implicit in robotics was not enough; students had to apply it to their own lives and reason through real-life situations. Students were asked to brainstorm situations echoing the same "missing pieces" feeling. The students were also challenged to relate robotics reflections to their school social lives and family members' frustrations with other adults at home or at work in terms of communication and collaboration. Students went into their homes and communities to talk about the robotics project and their team work attitudes.

The students did a set of interviews with parents to find out the extent to which their lives involve chosen teaming. This culminated in an oral history. Finally, the students were given the option of developing arguments for and against teaming on projects. Some referenced a parent's feeling that the parent has to do "all the work" because others "goof off" or "disappear." One student said he felt that at home as well. He is responsible for the rest of his siblings in terms of cleaning up and preventing fights while other older siblings who are supposed to share this responsibility focus on themselves. Some students boldly argue that working alone is better because they can focus on tasks or assignments themselves. They can get these tasks done independently. Since the STEM teachers, Carideo and Liotta, are deliberately teaching as a team, their partnership and the collaboration by choice with a team of colleagues was compared and contrasted with the solo teachers.

Some students shared the pleasure of spending time on intricate jigsaw puzzles, only to be left unable to complete them because of "missing pieces." Students confessed to telling stories at school or to parents with deliberately missing pieces. For some students in search of birth parents, there were missing pieces. Discussion was reciprocal. The teachers shared the endless feedback and customizing of curricula for students that goes with teaching. They also considered how friendships, family relationships and even schools required ongoing and continued work to run well, far beyond what was originally anticipated as needed.

Once the students had vented their frustrations, the discussion and

reflective writing focused on how they had dealt with that frustration. Had they "fixed" the issues or problems or in some way bypassed them to get to successfully build a functioning robot? Their solutions were at first connected to robotics domain-specific issues.

Groups frustrated by the loss of crucial kit pieces brainstormed organizing and inventorying kit pieces by type and color. This facilitated tracking of the pieces so that any loss could be followed by focused search. The following classroom snapshot highlights some of the challenges students overcame during the project:

Shanay realized that programming the right codes required careful detailed reading of all the code descriptions. She personally undertook that task with another team member. This self-directed initiative led to identifying all the correct codes.

Joseph identified a leadership role as the scheduler/organizer. He scheduled each team member for four turns at building and four turns at programming. Most complied.

Luna's team applied the ELA class collaborative accountability speaking and listening conversations to group discussions about how things were going. As a team they came up with a plan to get their robot to work.

Janiah, who had initially vented frustration on the robot, reminded herself that she was the intelligent being in the equation. As she framed it, "It is not the robot's fault. It was my fault because I was doing something wrong." She disciplined herself to return to the computer. With this resolve, she was able to get the color sensors working. Having taken responsibility for her action, she was "really happy" when it worked.

The team with the mixed wire issue returned to the manual to get the wires placed correctly. The program actually worked, and that made all the difference in their mood.

Rashun came up with a plan for his team to have half the members build the robot and half start programming.

Azreen did change the name of the program to under 32 characters.

Several teams that had missing parts and couldn't find them simply went forward minus the parts, including a pivotal ball and a front bumper.

One team member tried delegating tasks, but when they weren't done, he wound up doing multiple tasks himself.

Just underscoring 21st century skills implicit in robotics was not enough; students had to apply it to their own lives and reason through real-life situations.

Since the journals and explicit discussion about aspects of the project beyond the robot-building had been a key element of the project, students could understand how they were actually doing much more than just building a robot.

Applying Robotics to other Real-World Situations

Finally, students worked on "fitting" these robotics "fixes" to real life, including real-world frustrations. We called this 21st century applied learning. In a closing session, Reissman challenged students to apply this strategy of robotics "fixes" to a real-life, career or job challenge.

Inventorying turned out to be a job one student's uncle had at a local 99 cent store. Another student recalled a hardware store clerk who had a written inventory of screw types available with a back order list.

Scheduling was something students schoolwide were familiar with in terms of limited scheduled access to gym, art, lunch and lab use. Many without computers at home also had to schedule access to computers in the public library.

Reading a manual slowly and carefully without emotion was a strategy students had seen work successfully for their parents or adults when using or setting up tech/exercise equipment, furniture, programming a cellphone and other tasks. Several students shared with pride their ability to read and interpret manuals.

In discussing multitasking when delegating tasks had failed, students mentioned family members, teachers, and coaches who ultimately made certain things got done on time. They were asked to identify multitaskers versus true leaders of teams in the news and in books. The idea of meeting a deadline by getting out a product that was not exactly the desired product, but still a viable one, was floated. What in real life got done, but not exactly how it was planned? Student response to this took awhile. Finally, a student artist noted that a mural he worked on in another school came out great, but was not his original design.

21st Century Born

Since the journals and explicit discussion about aspects of the project beyond the robot-building had been a key element of the project, students could understand how they were actually doing much more than just building a robot. They were able to look at their journals and listen to peers apply the skills they had demonstrated to the real world.

Students in this project all developed journals that reflected information writing, CCSS standards and robotics special skills (for which a rubric was created). They also programmed robots which all functioned and were rated according to a rubric. The students' visual and verbal group presentations were rated by CCSS Speaking and Listening-aligned rubrics.

Students were pre- and post-surveyed about the extent to which this project might be related to academic and social/real-world learning beyond the classroom. After all these outcomes and rubrics and the robots themselves are viewed, what stands out as an immediately infusible practice is the way in which robotics allowed students to practice real-world 21st century collaboration, communications, and creativity, and experience real-world skills and outcomes, as they "studied" sixth-grade required ELA, science, engineering and mathematics skills during the school day. They were not learning these key cognitive skills in isolation, but rather doing them as real-world persons — 12-year-olds functioning as 21st century learners.

Programming 21st century learning does not require an outlay of cash or the purchase of expensive materials. Rather it can and should be done through a team of collaborating teachers modeling in their partnership the ways content skills meld together for problem-solving, strategizing, and addressing frustrations. Robotics-building is an example of one ready opportunity for staff and students to engage in 21st century learning.

School curriculum maps are filled with other project-based literacy learning opportunities that can connect teachers as teams and students as peer-dependent teams working together on real-world products and productions during school time.

Robotics-building is an example of one ready opportunity for staff and students to engage in 21st century learning.

References

Demetriou, G. A. (2011). Mobile robotics in education and research. Retrieved from: *http://www.imls.govt/about/21st _century _skills_list.aspx*

Gura, M., & King, K. (2007). *Classroom robotics-case studies of 21st century instruction for millennial students.* New York: Information Age Publishing.

Gura, M. (2012). Lego robotics STEM sport of the mind. Retrieved from: *http://www.learningandleading-digital.com/learning_leading/201208?folio=12#pg14*

Gura, M. (2013). Student robotics and the K-12 curriculum. Retrieved from: *http://www.edutopia.org/blog/student-robotics-k-12-curriculum-mark-gura*

Khanlari, A. (2013). Effects of robotics on 21st century skills. Retrieved from: *http://warse.org/pdfs/2013/icet4esp10.pdf*

Additional resources recommended by the author:

Classroom Robotics Blog. Retrieved from: *http://classroomrobotics.blogspot.com/*

Partnership for 21st Century Skills. (2011). Framework for 21st century learning. Retrieved from: *http://www.p21skills.org*